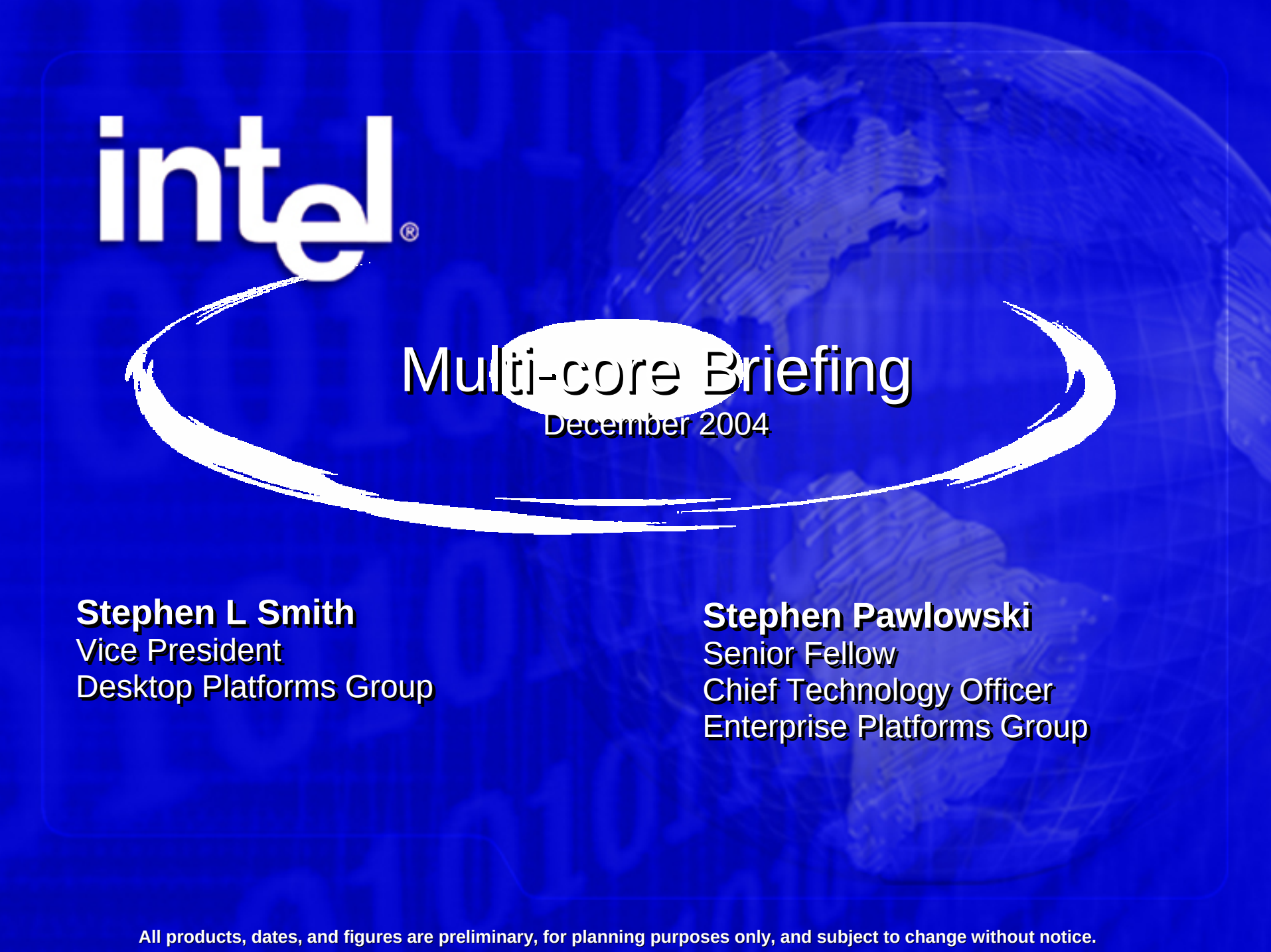


Multi-core Briefing

December 2004

Stephen L Smith
Vice President
Desktop Platforms Group

Stephen Pawlowski
Senior Fellow
Chief Technology Officer
Enterprise Platforms Group

Agenda

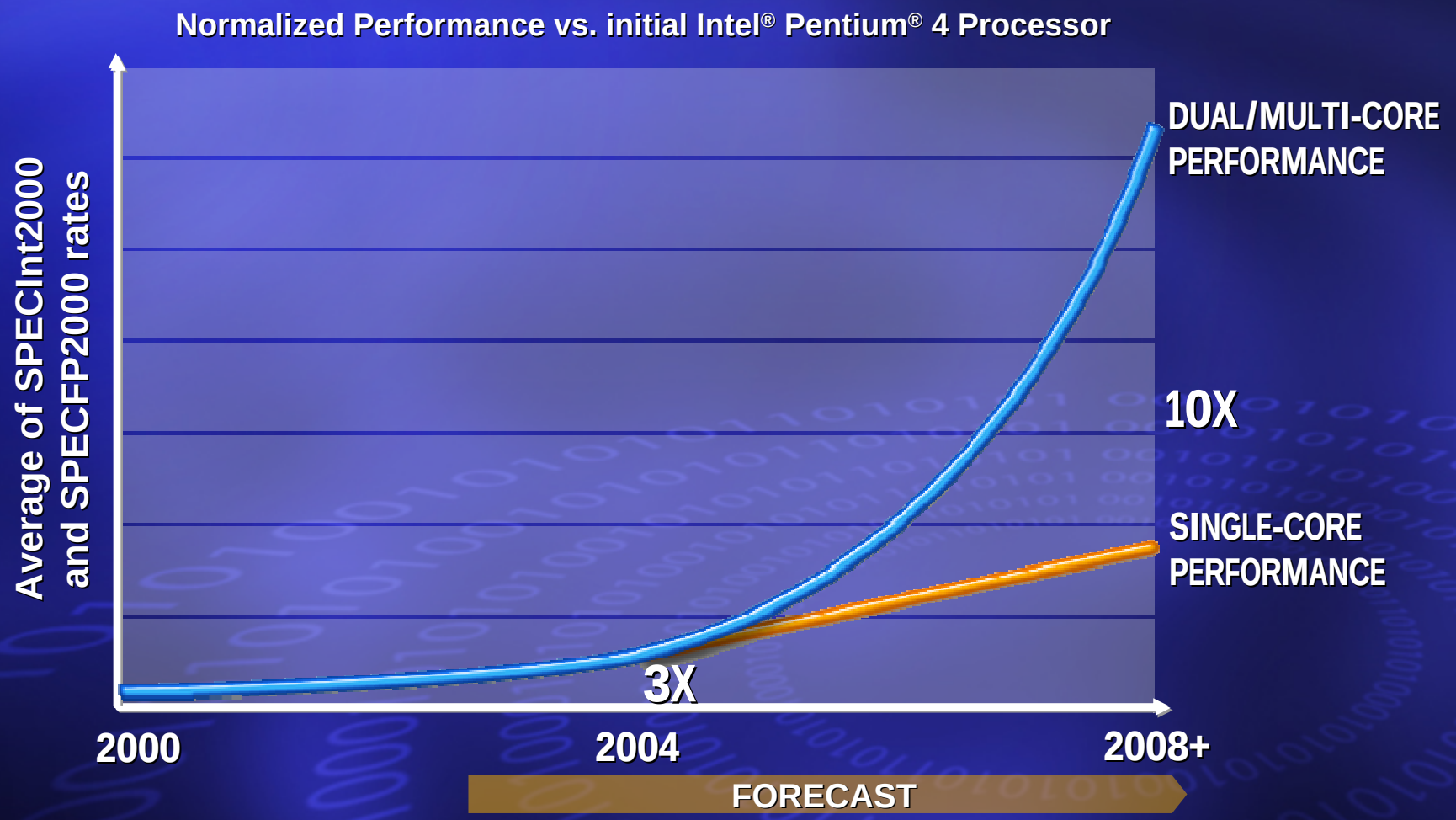
- Intel Threading/Multi-core History & Strategy
- User Benefits of Enhanced Threading
- Intel 2005/2006 Threading/Multi-core Plans
- Beyond the Horizon
- Summary
- QA

End Goal: Increase User Experience

- Moore's law provides the opportunity for continual platform enhancements
- Opportunity: Maximize use of growing transistor budgets
  - Best value to end users
  - Improvements in response time & compute throughput
  - New platform features and capabilities - *Ts, wireless, cache,..
- Intel's ongoing focus: Driving hardware enhanced thread level parallelism
  - Higher compute throughput & scalable for future
  - Balanced Platform – Bandwidth, connectivity and ease of use

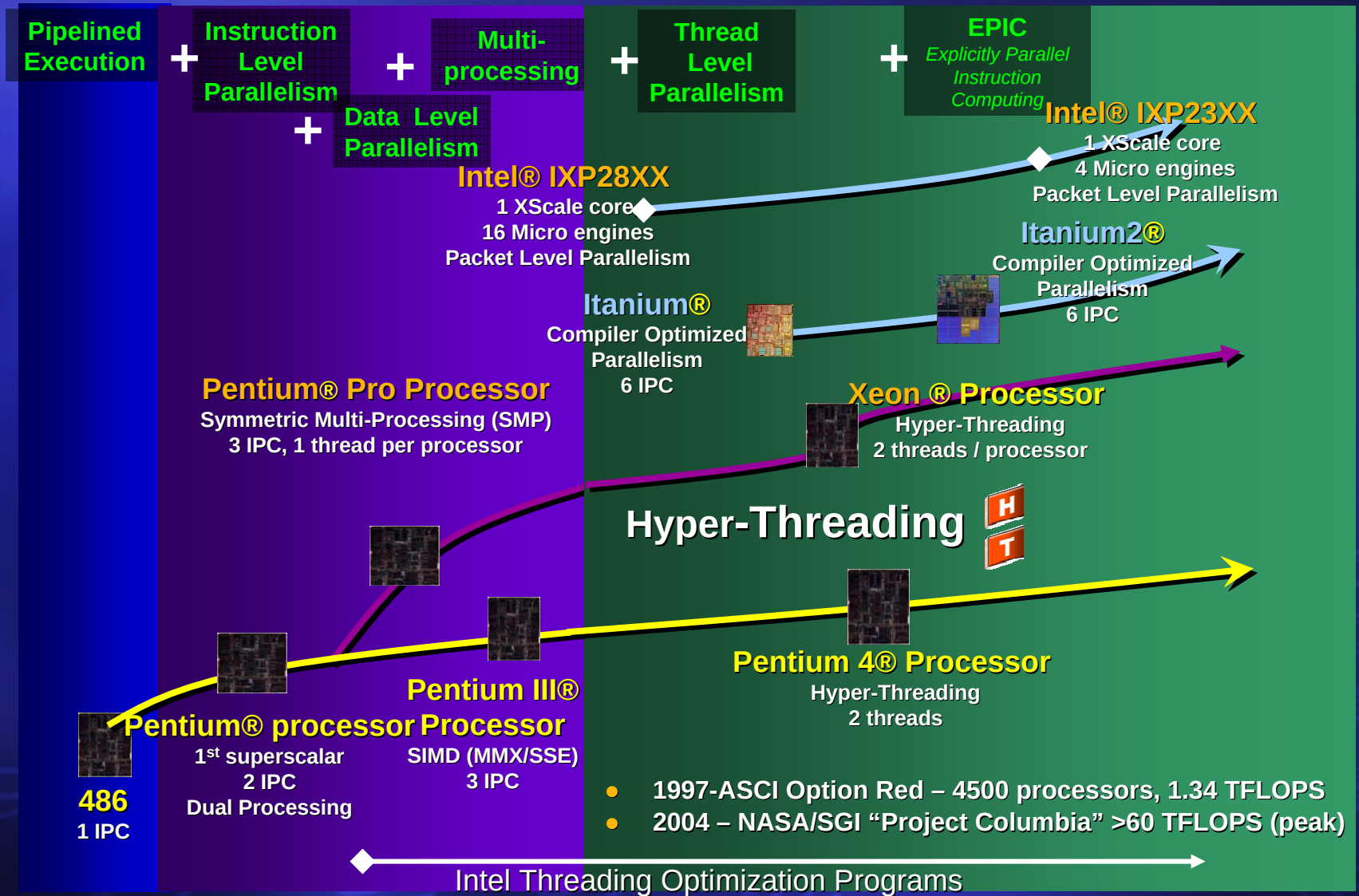
Intel Strategy: Driving Greater Parallelism

PERFORMANCE Through Parallelism



Source: Intel

Increasing Degrees of Parallelism



Long History in Exploiting Parallelism

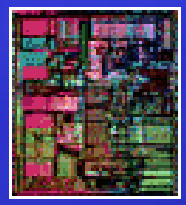
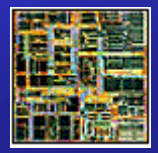
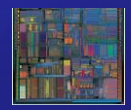
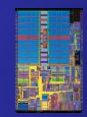
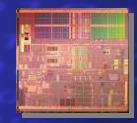
Intel Strategy – Driving Thread Parallelism

- HT: Better parallelism via utilization of existing resources
  - Volume server and desktop in 2002
  - Continued thread enabling programs
- Dual Core: Powerful evolution of HT that provides 2 full execution cores in a single processor
  - Volume ramp across all segments
- Future Multi-core: Continued processor level parallelism with >=2 cores in a single processor
  - Continued scale with Moore's Law for future volume prods

Delivering 'Threading' in Volume

>50Mu HT units shipped (9/04)

Moore's Law in Action
Example: Desktop

Silicon Process Technology	0.8µ	0.6µ	0.35µ	0.25µ	0.18µ	0.13µ	90n	65n
Pentium® Processor								
Pentium® II/III Processor								
Pentium® 4 Processor								
Next Gen							90nm Dual Core	65nm Dual Core

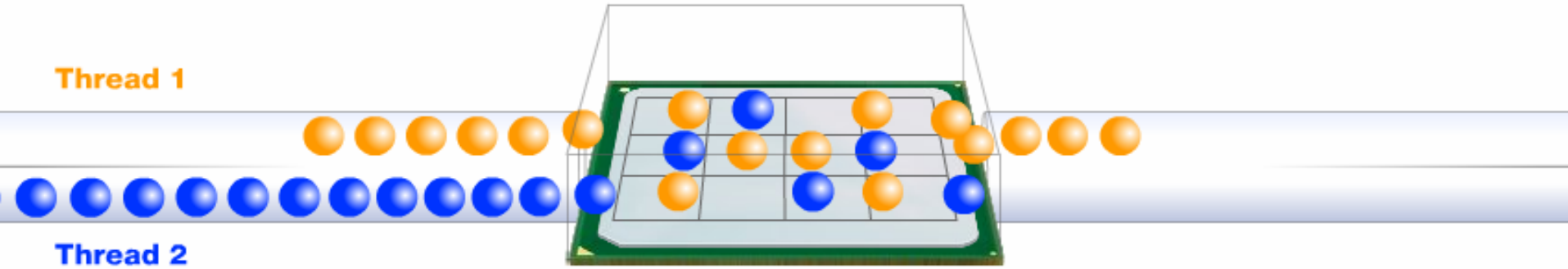
Dual Core: In Line With Historic Generations
Enables Volume Die Sizes

Source: Intel

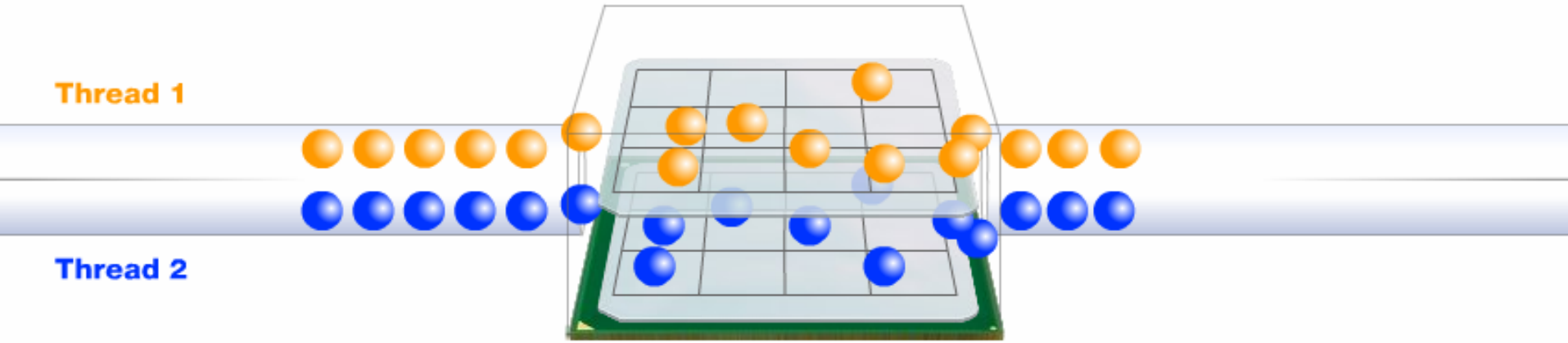
Hyper-Threading Technology and Dual Core

Comparing Processor Utilization

Intel® Pentium® 4 Processor with HT Technology



An Intel® Dual Core Processor enables each thread to be processed in its own core for truly parallel execution.



Intel® Dual Core Processor

Demonstration reflects data processing simulation for illustrative purposes; actual data processing flow may vary.

Animation
Demo

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…more than MHz

WAS…

MHz, MHz, MHz

IS…

User Features & Capabilities

Wireless, Security, Form factor,
Reliability, Stability, Battery Life, & Performance

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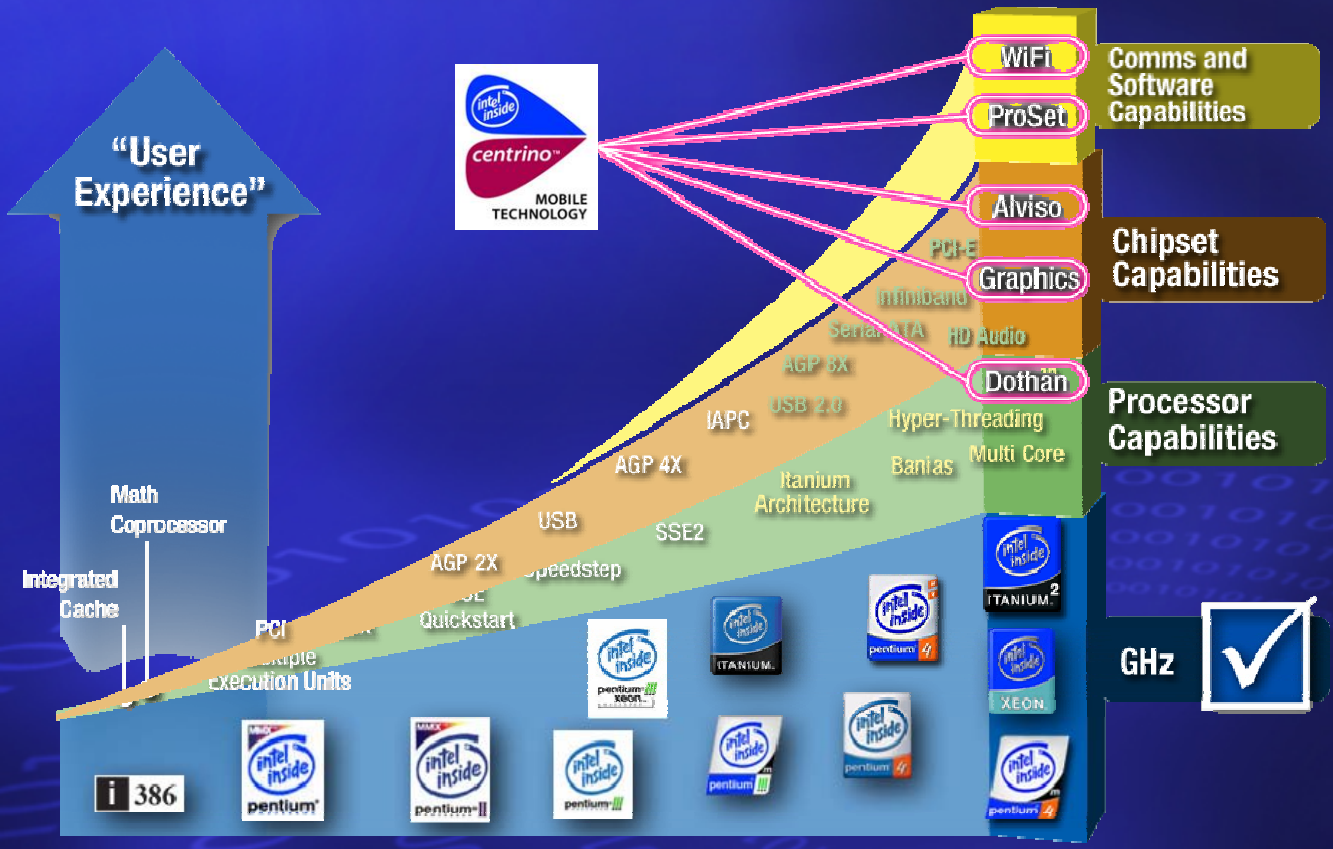
the Platform-ization of Intel



Similar Approach in Servers and Desktop

Potential Benefits of Improved Thread Parallelism

- Improved multi-threaded application performance
  - Client: HT can deliver up to 25% gain today
    - http://www.intel.com/performance
  - Server: HT can deliver up to 30% gain today
    - http://www.intel.com/business/bss/products/hyperthreading/server/ht_server.pdf
- Improved Responsiveness in Multi-tasking environments
  - Concurrent foreground apps and foreground/ background processing
  - For details see Responsiveness White Papers
    - http://www.intel.com/performance/resources/briefs/HTBasSecWP.pdf
    - http://www.intel.com/performance/resources/briefs/HTOfficeWP.pdf

Expect Dual/Multi-core will Expand Upon the Benefits Enabled by HT Today

Example Today: DT Benefit of Threading with HT

Background application:

User is working on PowerPoint 2003* and compresses images prior to emailing the presentation

Foreground application:

While waiting for PowerPoint* to complete, user starts Adobe Reader 6.0 to read a PDF document

2.7x Faster Response Time with HT-ON

Without HT technology

With HT technology

Expect Dual/Multi-core to Expand upon Multi-tasking Benefit Enabled by HT on the Client

Configurations and Disclaimers

Source: http://www.intel.com/performance/resources/briefs/HTOfficeWP.pdf Testing Configuration from source: Intel® Pentium® 4 processor with HT Technology, 2.8 GHz on Intel® 82865G chipset – Dell* 0U1324, Samsung* 512MB PC2700 DDR333, Graphics Chipset: Intel 82865G 96MB, Graphics Driver: 6.14.10.3762, Intel chipset software installation file (INF): 5.01.1015, Hard Disk: Maxtor 6E040L0 41110MB (7,200 rpm), 6.14.10.3762, DirectX* 9.0b, Windows* XP Build 2600 SP1 NTFS, Intel PRO/1000 MT; *Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance.*

Parallelism in the Digital Home

Enhanced User Experience* 'Enjoy'

Multimedia

- Edit, create, share: music, videos, and photos

Multi-Task

- Enjoy multimedia, gaming, IM, browsing, ..

…while

…While Transparently Running Multiple Background Applications

Protection:
Virus Scan
Firewall
Data backup
Data encryption

Platform Health/Operation:
Automatic Downloads
OS Updates and services
Compression

Content Management:
Transcode to different formats
Delivering multiple streams
Record content to the hard drive (PVR)

**Performance improvements relative to single threaded CPUs in similar market segment*

Example: Parallelism in the Digital Home

Record TV show through PVR + **Playback DVD movie or play PC game** + **Stream content to Digital Media Receiver device**

Parallelism in the Digital Office

Potential client threading benefits

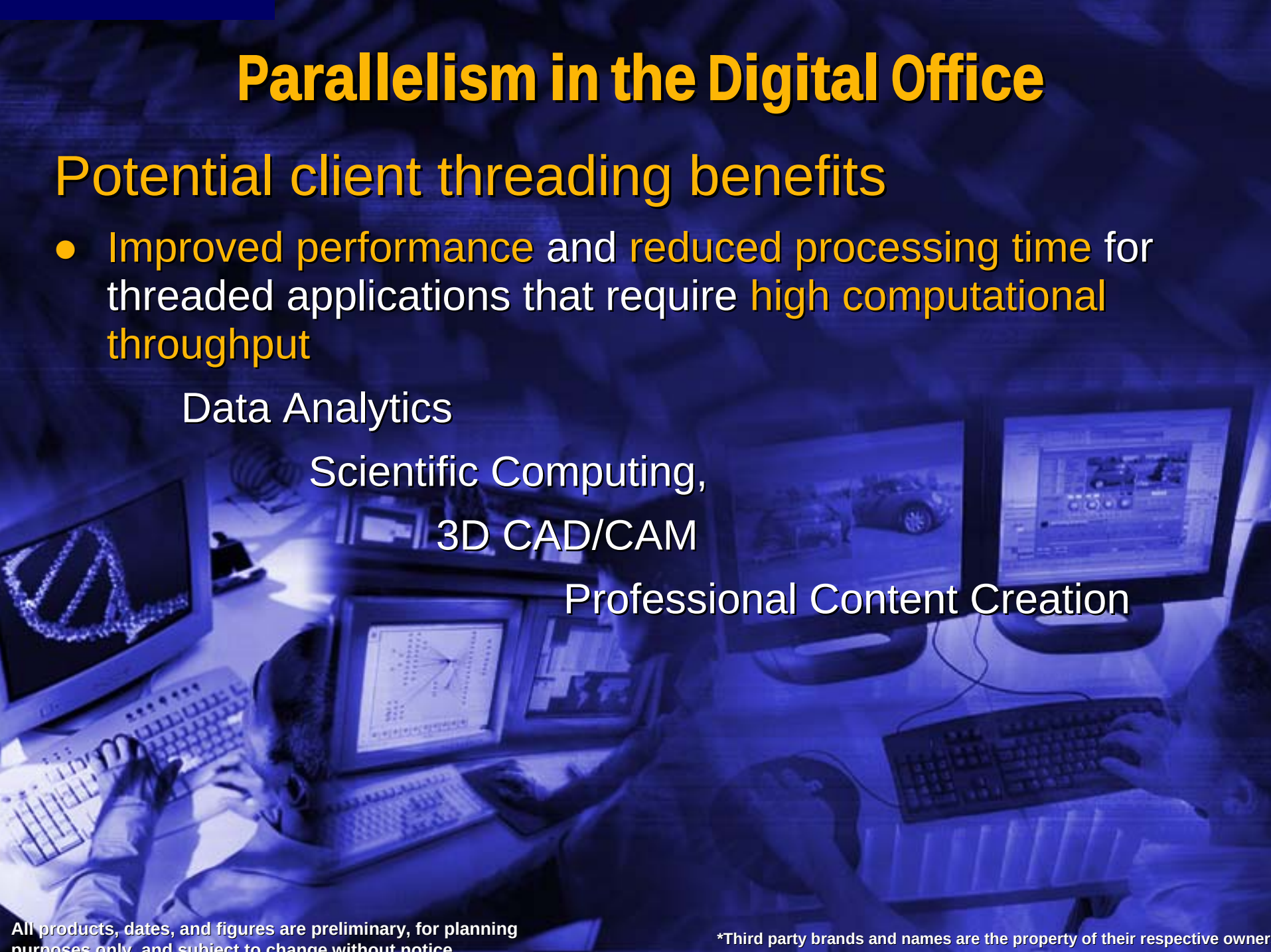
- Improved performance and reduced processing time for threaded applications that require high computational throughput

Data Analytics

Scientific Computing,

3D CAD/CAM

Professional Content Creation



Parallelism in the Digital Office

Potential client multi-tasking benefits

Demand Will Continue to Grow

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Intel..... *Driving* Parallelism

Utilizing Core Intel Strengths:

- Capacity, Technology, Power Management, Enabling, Worldwide Channels, Brand

Delivering in Volume:

	2004	2005	2006*
Desktop Performance	65% HT	Shipping dual core	>70% dual core
Servers	100% HT	Shipping dual core	>85% dual/multi-core
Mobile Performance	Mobile Optimized Micro-Arch	Shipping dual core	>70% dual core

* data is projected run rate exiting the year. Source: Intel

Driven by Evolving User Needs

Napa: Next Generation Mobile Platform

Yonah – *Intel's 1st mobile **dual core** CPU, **65nm** with **power management capabilities** and **enhanced performance** for multiple intense apps & multi-threaded applications – shipping in late 2005*

Calistoga – *Improved integrated graphics with **enhanced display & media features** delivering superb playback performance*

ICH7-M – *New mobile I/O controller hub, up to **6 PCI express ports** and **enhanced power management features** for power savings*

Golan – *Next generation wireless supporting **latest industry security standards**, **mini-card** form factor for smaller designs*

Future Platforms:

–Future Mobile Optimized Micro-Architecture Multi-Core Designs

Intel Multi-Core Processors – Server and Desktop

Desktop

- Smithfield in 2005 – Dual Core on 90nm
- 65nm in 2006
- Future Multi-core Desktop Designs

Server

- Dual Core ships in ’05 - driving rapid enterprise ramp of dual-core in ’06
  - Montecito, Itanium processor family dual core, shipping to OEMs in 2H’05
  - Optimized Xeon DP platform featuring dual-core in Q1’06
  - Continue Xeon MP platform longevity adding dual-core in Q1’06
- Future Multi-core designs including 2 and more cores
  - IPF: Montvale, Tukwila, Dimona
  - Xeon: Tulsa, Whitefield

Unique Dual/Multi-Core Products in All Segments

The Intel you might not know...

Software and Solutions Group

1 group • 6 divisions • 14 time zones • 24 major sites

Mission:

Enhancing the value of IA platforms through architecture, performance, practices, and ecosystem influence

Software Development Tools **Managed Run Time Enabling**

Software IP Strategy **Architecting Solutions & Services**

Strategic Enabling **Parallel & Distributed Solutions**

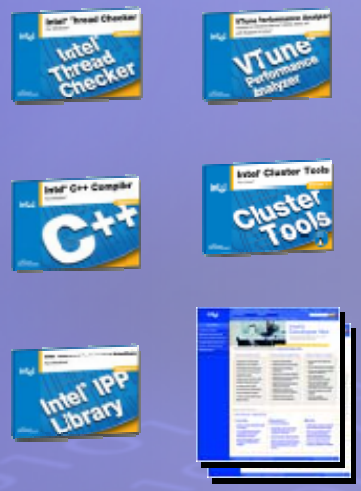
Software Enabling & Developer Services **Platform Planning**

Intel Threading Enabling Program

Dev Platforms

HT enabled platforms

SW Tools and Expertise



Intel Threading Toolkit, Whitepapers, Training

Volume production

HT/Dual/Multi Core

	2004	2005	2006*
Desktop Performance	65% HT	Shipping dual core	>70% dual core
Servers	100% HT	Shipping dual core	>85% dual/multi-core
Mobile Performance	Mobile Optimized Micro-Arch	Shipping dual core	>70% dual core

~165 HT enabled client apps
Support in modern OSes

Ecosystem: Accelerating Thread Parallelism

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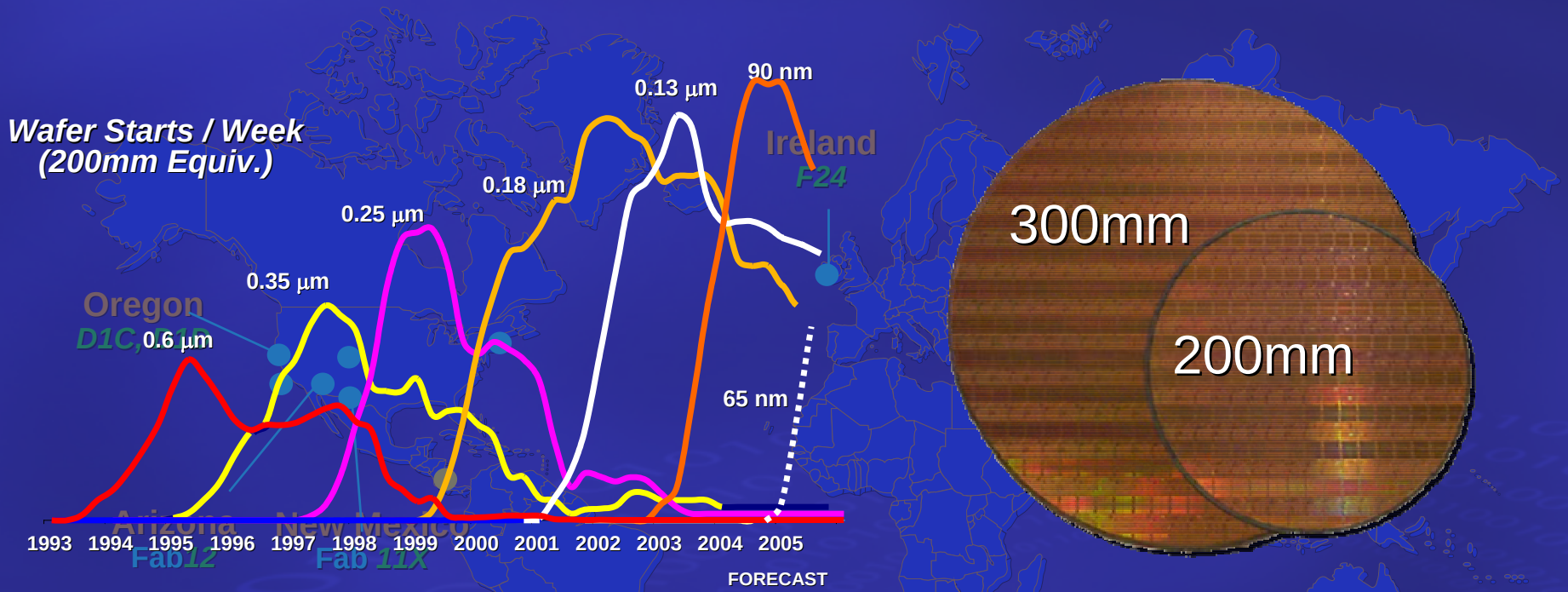
Intel 300mm Ramp Capability



Worldwide Manufacturing and Sales Channels

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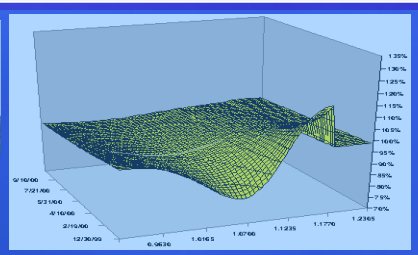
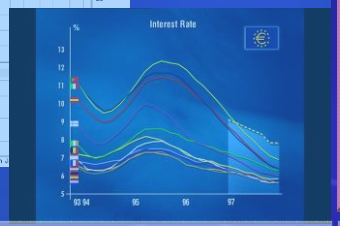
The RMS View

RMS: Emerging general purpose workloads that will drive the need high performance platform architectures

Digital Market

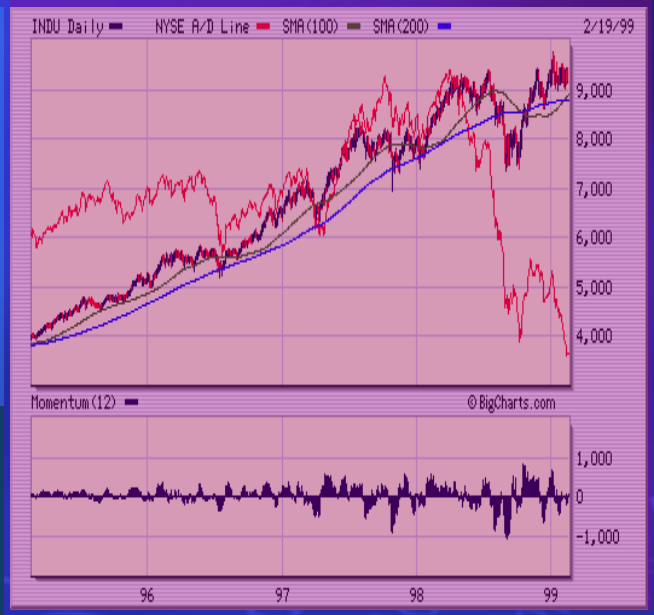
Recognition





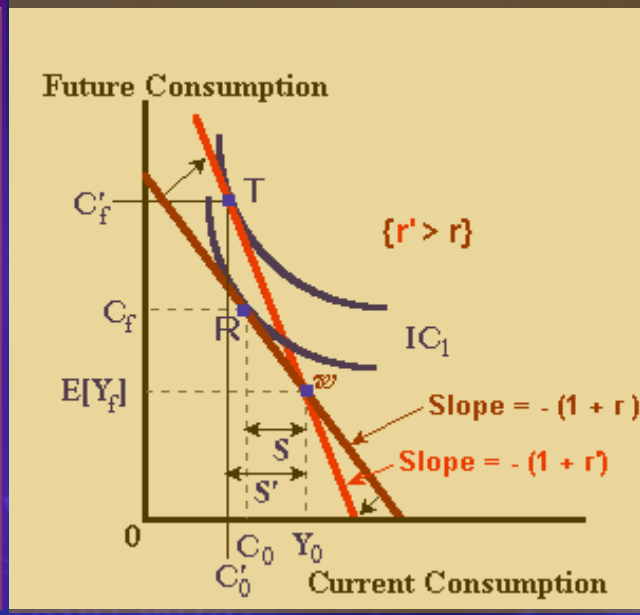
What is hedging?
What is equity?
What is interest-rate?

Mining



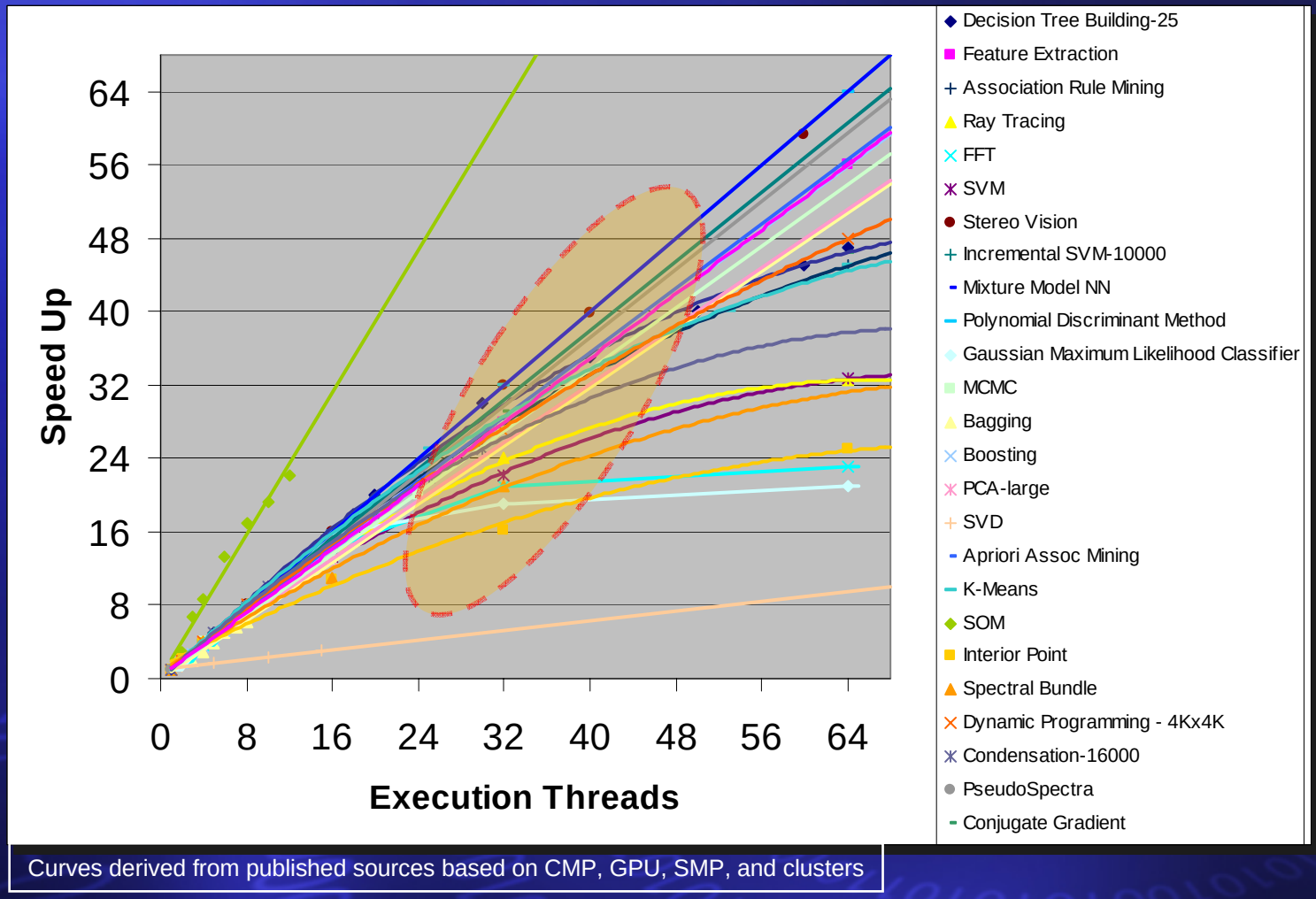
Is there a *hedging* opportunity here?

Synthesis



What if interest-rates were to go up?

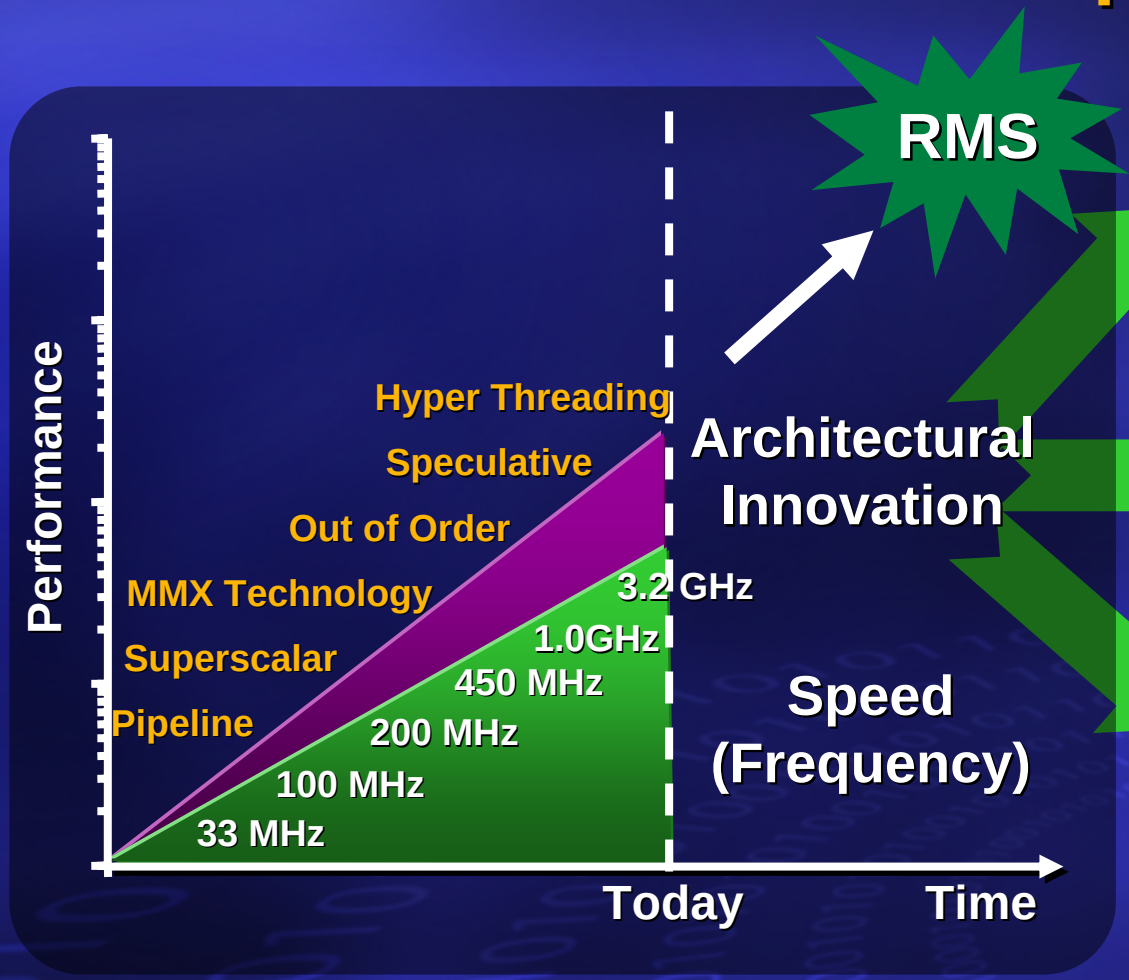
Thread level parallelism in RMS



Curves derived from published sources based on CMP, GPU, SMP, and clusters

RMS workloads should scale well to 100s of execution threads

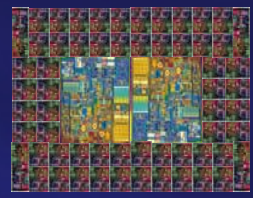
New Architectural Approach



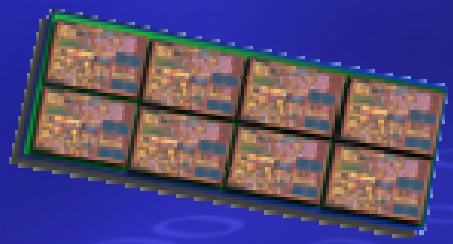
Value = Performance + Architectural Innovation

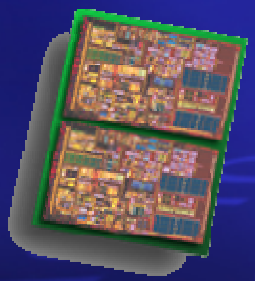
Scalability

Scalar plus many core for highly threaded workloads



Large, Scalar cores for high single-thread performance





Many-core array

- CMP with 10s-100s low power cores
- Capable of TFLOPS+
- Full System-on-Chip
- Servers, workstations, embedded…

Multi-core array

- CMP with ~10 cores

Dual core

- Symmetric multithreading

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Multi-Core: Recipe for Success

- R&D
- Technology
- Power Management
- Enabling
- Capacity
- Worldwide Channels
- Brand

Q&A